GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. _____

Project No. G-35-612 (R5944-0A0) GTRC DATE 5 / 23 / 85

Project Director: Dr. G. W. Grams School/ Geo. Sci.

Sponsor: National Oceanic and Atmospheric Administration (NOAA)

Type Agreement: P. O. No. 43-RANR-5-04753 and Modification No. 1

Award Period: From 4/4/85 To 4/3/86 (Performance) 4/3/86 (Reports)

Sponsor Amount:	This Change	Total to Date
Estimated:	$ 20,000	$ 20,000
Funded:	$ 20,000	$ 20,000 (Fixed Price)

Cost Sharing Amount: $ None Cost Sharing No: N/A

Title: Stratospheric Aerosol Effects in Umkehr Ozone Profiles

ADMINISTRATIVE DATA OCA Contact Brian J. Lindberg X4820

1) Sponsor Technical Contact:

Dr. John J. DeLuisi
Environmental Research Lab., Code R/E1
National Oceanic & Atmospheric Admin.
325 Broadway
Boulder, CO 80303

2) Sponsor Admin/Contractual Matters:

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Admin.
325 Broadway
Boulder, CO 80303
(303) 497-5101

Defense Priority Rating: N/A Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

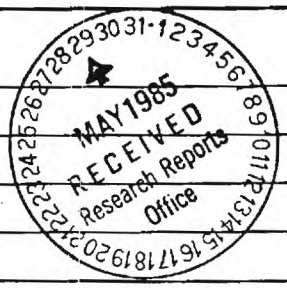
RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated

COMMENTS:



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Accounting	Research Communications (2)	Other Jones

FORM OCA 65 285

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

2-N-B
5R906

Date 4/30/86

Project No. G-35-612 School/Lab Geo. Sci.

Includes Subproject No.(s) N/A

Project Director(s) G. W. Grams GTRC /

Sponsor National Oceanic and Atmospheric Administration (NOAA)

Title Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Effective Completion Date: 4/3/86 (Performance) (Reports)

Grant/Contract Closeout Actions Remaining:

- ☐ None — Fixed Price
- ☒ XX Final Invoice or Final Fiscal Report
- ☐ Closing Documents
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other

Continues Project No. Continued by Project No.

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E. Embry

FORM OCA 69.285

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332
July 23, 1985

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley,

Here are the first four progress reports for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for April and May 1985

The SAGE (Stratospheric Aerosol and Gas Experiment) data tapes that we processed during the summer and fall of 1984 contained a systematic high altitude temperature error. In early 1985, upon receiving a set of SAGE data tapes that had been corrected for this temperature error, we decided to implement a change of vertical coordinate from geopotential height to pressure level. We chose the pressure levels to correspond to the standard Umkehr layers in order to facilitate joint analysis of both data sets. To create the desired data matrices, we developed an interpolation routine that is linear in log pressure, assumes hydrostatic balance, and operates on the SAGE data to produce ten matrices of data. The output matrices are 60 layers in vertical extent and include 2,290 profiles for sunrise events or 14,939 profiles for sunset events. Each matrix uses linear interpolation between nearest neighbors to replace missing profiles. The error estimates for these missing data are large enough to prohibit their having an influence on a weighted analysis of the data. The ten quantities are two identification files; extinctions at 1.0, 0.6, 0.45, and 0.38 microns; mixing ratios for ozone and NO_2; temperature; and 1.0 micron Rayleigh extinction.

Because of the relatively large number of SAGE data, we spent a considerable amount of effort assuring that the interpolated data were processed correctly and that the interpolation scheme did not distort the various profiles. At the end of this month, we are still plotting interpolated results versus original data to insure that our routines are operating properly.

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for June 1985

This month, we completed the validation of the interpolation routines and began processing the new SAGE tapes. Each of the SAGE tapes contains one month of data with all information for a given measurement event stored on a single record. A typical month contains 15 sunrise and 15 sunset events per day for a total of about 900 events. Because of a power failure, SAGE recorded only sunset events after July 1979. The missing events are not included or indicated on the data tape. Our routine separates the data into ten different random access files for sunrise events and ten files for sunset events. Missing events are filled with nearest neighbor interpolation and large error estimates. Each of the 34 SAGE tapes are processed sequentially, adding to each of the random access files another month of data.

One of the difficulties that we encountered is that magnetic tapes are subject to parity errors (imperfections on the tape or tape drive problems), which if left unchecked, dilute the amount of usable data captured. Sometimes a tape was processed several times to obtain a run free of parity errors. While this approach requires more time than simply ignoring the parity errors, we felt that the time was well spent. Another problem involved the size of the growing data files and limited space on the computer storage devices. By the end of this month, we were nearly finished building our random access data files from the 34 SAGE tapes.

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for July 1985

This month, we finished processing the last of the 34 SAGE tapes and started a statistical analysis of the newly generated random access data files. The first variable that we considered was the 1.0 micron aerosol extinction at the 72 mb level. Using BMDP statistical routines, we examined sunset events 19-238 to find the distribution of the data and their coefficients of variation. These data served as a test for the applicability of BMDP to our data set and proved that the routines would be quite useful.

An analysis of the 1.0 micron aerosol extinctions at 72 mb reveals that the mean coefficient of variation is 0.14 (i.e., 14% error bars), with very few greater than 0.20. This indicates that, at least near the aerosol peak, the SAGE data will be very useful. Because analysis of the extinction data indicates that they are neither normally nor log-normally distributed, we must be cognizant of significant regional and temporal deviations from the mean.

Testing the three longest sequences with fewer than six missing events for the distribution and autocorrelation of the data, we find that two of the series are normally distributed stationary series and one is not. In order to allow for the variation in the data precision, we have written a weighted autocorrelation routine which we have applied to these three series. The results indicate that the choice of series must be governed by the stationarity along with physical considerations.

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
August 28, 1985

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley,

Here is the fifth progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for August .1985

We have grouped the SAGE events into three latitude bands (divided at 30°) to determine autocorrelations. For each series of approximately 200 events with fewer than 5% missing within each of these bands, we calculate the autocorrelation weighted by the standard errors of the individual data. For lags 1 to 47 (lag 15 ≅1 day) we calculate the arithmetic average of the autocorrelations and the 95% significance levels. Each band typically includes 10 - 15 series and displays significant autocorrelations at lags 1, 2, and 14 or 15. We will use these results to determine the confidence associated with the spatial interpolation using nearest neighbor, previous day, or following day SAGE events to approximate the conditions over an Umkehr observation.

Planning to use SAGE events within at least 1 day and 1000 km of an Umkehr observation, we have found all of these coincident events during the life of SAGE. These comprise approximately 160 cases that will provide the nucleus of the aerosol effect study.

We also converted the CDC coded SAGE data that we have been using for our work into ASCII coded files, copies of which may now be made for interested scientists. These files reside on nine 2400 foot 9-track tapes.

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
October 1, 1985

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley,

Here is the sixth progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for September 1985

Correction to August report: Coincident SAGE-Umkehr events comprise 271 cases NOT 160 as previously reported.

After studying the available SAGE events for the 271 coincident cases, we computed the correlation between known SAGE events and a linear combination of SAGE events at lags 1, 14, and 15, anticipating an improvement over the correlation with a single event. The linear combinations, however, are not significantly better than the lag 1 correlations over all levels for a given variable (ozone, 1 micron extinction, or .45 micron extinction) in any of the three latitude bands. Therefore, when a SAGE event within 1000 km and at the same time is available, that event will represent our best estimate of the conditions over the Umkehr station at the time of the Umkehr observation. When one or more events are available at a 12 or 24 hour displacement, and within 1000 km, a simple average of the available SAGE profiles will serve as the best estimate of the Umkehr conditions.

Using these criteria, we computed the means and standard deviations of 1 micron optical depth, .45 micron optical depth, and the differences of SAGE and Umkehr ozone for all 271 cases. Limiting the study to the 65 Arosa cases or the 25 Boulder cases does not alter the results very much. Histograms of the ozone partial pressure differences as a function of Umkehr layer are highly skewed as are the histograms of the optical depths. This skewness indicates that a case by case analysis is necessary to determine the relationship between ozone differ-

ences and optical depth. We presented a report of the work done to date at the SAGE science team meeting October 1 in Atlanta, Georgia. A copy of this report is being sent to Dr. DeLuisi under separate cover.

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
November 1, 1985

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley:

Here is the seventh progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for October 1985

Having found significant differences between SAGE and Umkehr ozone profiles at all levels, we plotted those differences against various independent variables searching for a relationship. Plotting percentage ozone differences versus stratospheric optical depth at both 1.0 micron and 0.45 micron revealed no discernable pattern at any level. Typical optical depth maxima were 0.005 at 1.0 micron and 0.02 at 0.45 micron. Plots of percentage ozone differences versus station, total ozone, month, latitude, longitude, or distance between SAGE and Umkehr instruments failed to indicate any cause for the consistently high SAGE ozone values. In one case at Perth, where the 1 micron stratospheric optical depth was 0.05 (the highest case found), the SAGE ozone amounts were lower than Umkehr amounts, contrary to both the general case and the expected conditions.

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
December 1, 1985

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley:

Here is the eighth progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for November 1985

Because the optical depth at approximately 0.32 micron is the aerosol parameter of most interest in the Umkehr correction, and because an analysis of 1.0 micron and 0.45 micron optical depths revealed nothing interesting, we are attempting to determine the 0.32 micron optical depth. The first attempt is an extrapolation, linear in the natural logarithm of wavelength. This is a power law relationship that exhibits wavelength exponents between -1.5 and -2.2 for the 121 cases with 0.32 micron stratospheric optical depths greater than 0.3 and distances between SAGE and Umkehr observations less than 4000 km. We are currently plotting these data, as we did for the previous cases, in search of a cause for the ozone differences.

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
January 1, 1986

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley:

Here is the ninth progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for December 1985

An error-weighted autocorrelation function (WACF) of the SAGE I data in appropriate latitude bands provides a basis for developing a spatial interpolation of the SAGE I events in the proximity of an Umkehr observation. This WACF suggests that in mid-latitudes, for the three variables of interest (ozone mixing ratio, 1 micron aerosol extinction, and 0.45 micron aerosol extinction), we use SAGE I events within 4000 km and 10°latitude weighted by the factor (1-distance/4000) and then normalized. In the tropical band, the weighting factor is (1-distance/5000) but only events within 4000 km are included. This procedure produces 354 cases of co-located SAGE I - Umkehr observations. A corrected procedure for assessing the SAGE I ozone partial pressures in Umkehr layers alters the previous reported SAGE-Umkehr ozone differences. Analysis of the distributions of percentage ozone differences suggests that we remove those cases that have values larger than four standard deviations from the mean on any particular layer. We also removed those stations that had fewer than three coincident cases. Some results for the remaining 337 cases are in the table below.

Scatter plots of the differences in layers two through nine versus station, latitude, ozone amount, and stratospheric optical depth suggest that a more rigorous analysis is in order to determine the relationship between the ozone differences and the various other quantities.

Table 1. Differences between SAGE and Umkehr ozone
% diff = 100 * (SAGE - Umkehr)/Umkehr ozone partial pressure

Layer	Avg of all 337 cases		
	Umk nb	SAGE I nb	%diff
9	6.7	6.4	-5.1
8	19.4	19.1	-1.3
7	45.4	44.2	-2.6
6	87.1	79.4	-8.8
5	127.3	123.2	-3.2
4	114.7	133.6	16.6
3	71.3	87.2	22.3
2	50.6	55.0	8.6
total	522.5	547.9	4.9

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
February 1, 1986

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley:

Here is the tenth progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for January 1986

This month's work comprises a case study of the 377 co-located SAGE I and Umkehr events. Initial statistical analysis computed the means and standard deviations of all variables and the correlations of appropriate variables. Details of the regression analysis of the percentage difference between SAGE I and Umkehr layer ozone on all other variables, including layer ozone contents, layer optical depths, and stratospheric optical depth, are reported in a separate document. The regression analysis along with initial group analysis indicates that several variables are confounded in the percentage difference statistic. Further group study is necessary to determine the effects of these variables (e.g., latitude, longitude, total column ozone, season, and year).

G-35-612

Michael J. Newchurch
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332
March 1, 1986

Ms. Margaret Shelley
DOC/MASC, RAS/MC3
National Oceanic & Atmospheric Administration
325 Broadway
Boulder, CO 80303

Dear Ms. Shelley:

Here is the eleventh progress report for G-35-612 (R5944-OAO) Stratospheric Aerosol Effects in Umkehr Ozone Profiles.

Sincerely,

Mike Newchurch

Project G-35-612 (R5944-OAO)

Technical Monitor: Dr. J. J. DeLuisi

Project Director: Dr. G. W. Grams

Stratospheric Aerosol Effects in Umkehr Ozone Profiles

Progress Report for February 1986

Comparison of SAGE I ozone with NIMBUS 7 SBUV ozone indicates agreement in Umkehr layers six, seven, and nine in northern mid-latitudes, where most intercomparisons are made. Poleward of 50°, SAGE I and SBUV agree in layers seven and nine. However, in layer six poleward of 50° SAGE I ozone is approximately 10% higher than SBUV. In layer eight, where discrepancies between SAGE I and SBUV exist at all latitudes north of 30°, a LIMS/Umkehr comparison at Arosa, Tateno, Boulder, and Belsk suggests that SAGE I and LIMS are in very close agreement. This implies that SBUV is approximately 8% too high in layer eight. Adoption of the new ozone absorption cross-sections in the SBUV inversion would alleviate most of this discrepancy.

Using only the 241 cases north of 30° from the global set of 337 co-located SAGE I/Umkehr profiles, extensive group analysis indicates that in the lower layers (two through five) the layer ozone differences are strong functions of both total column ozone and of season. In the upper layers (six through nine), differences are not influenced by total column ozone or by season. However, ozone differences are sensitive to stratospheric aerosol optical depth at 0.32μ . This aerosol effect is undetectable when the stratospheric optical depth at 0.32μ is less than approximately 0.025. Above this threshold, the layer ozone differences be-

tween SAGE I and Umkehr begin to increase, but only in the upper layers. Therefore, except after relatively large volcanic eruptions, the Umkehr profiles require no aerosol correction at all. Trend studies that use Umkehr data, excluding periods of unusually high volcanic activity, are justified in ignoring any aerosol effect in the ozone profiles.

All cases north of 30° are separated into two stratospheric aerosol optical depth groups at 0.32μ : low optical depth (less than 0.025) and high optical depth (greater than 0.025). In the lower layers, no aerosol effect is apparent. In the upper layers where the seasonal and total ozone effects are absent, the high stratospheric aerosol optical depth cases have more negative ozone differences between SAGE I and Umkehr (SAGE I ozone lower than Umkehr ozone) than the low stratospheric aerosol optical depth cases. The magnitude of this bias varies monotonically from 3% in layer six to 8% in layer nine. Results of a similar analysis for 0.045μ stratospheric aerosol optical depth reveal the same trend at somewhat lower absolute values. Because both the correlation and regression analysis indicate that the SAGE I ozone data are independent of the SAGE I aerosol data represented as either optical depths within Umkehr layers or total stratospheric optical depth, we attribute the differences to an aerosol effect on the Umkehr profiles. This aerosol effect, causing an apparent increase in the Umkehr ozone amounts, acts in a direction opposite to that predicted by theory. Furthermore, trend studies that have allowed for an aerosol effect that causes an apparent decrease in Umkehr ozone would fail to find significant ozone depletion trends in the upper Umkehr layers had they assumed that the aerosol effect causes an apparent increase in Umkehr ozone.